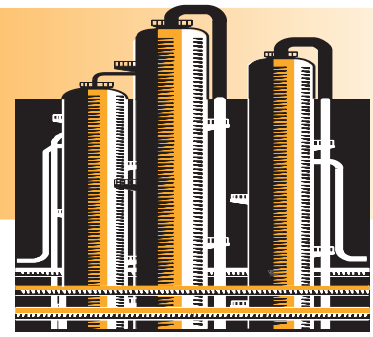


PETROLEUM

Project Fact Sheet



VERY LOW EMISSIONS: FORCED INTERNAL RECIRCULATION (FIR) BURNER

BENEFITS

- Very low NO_x emissions which are less than 9 vppm without using diluents such as steam, water, or external flue gas recirculation
- Increased system efficiency, with operation at less than 10 percent excess air over the entire turndown range of four to one
- Reduced developmental, operating, maintenance, and capital costs in comparison to "current generation" low- NO_x burner systems
- Burner design is suitable for new or retrofit applications to a wide range of combustion chamber configurations

APPLICATION

The FIR burner was evaluated on a 20 mm British thermal units (Btu) per hour boiler at Detroit Stoker Company and is being scaled up to 60 mm Btu per hour boiler for evaluation in Southern California.

FIR BURNER WILL YIELD A SIGNIFICANT REDUCTION IN EMISSIONS COMPARED TO CONVENTIONAL BURNER TECHNOLOGY

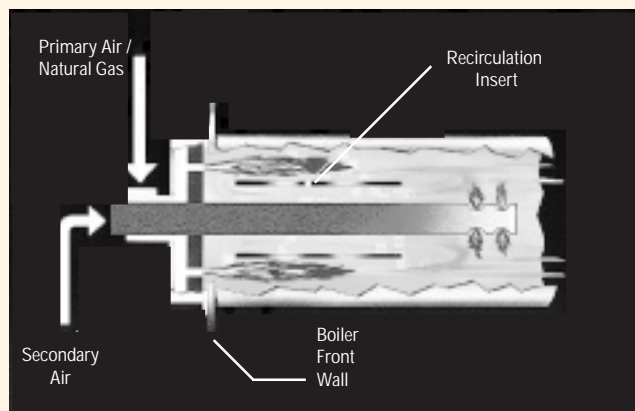
The generation of steam by America's manufacturing industries uses more energy than any other industrial process. While significant progress has been made in developing burners to meet the requirements of the 1990 Clean Air Act Amendments, the current technologies utilize either external flue gas recirculation, water or steam injection, or post-combustion treatment for nitrogen oxides (NO_x) reduction. These conventional techniques result in efficiency losses and increased capital, maintenance, and operating costs. The FIR burner is being developed to provide less than 9 volumetric parts per million (vppm) NO_x without any efficiency penalties.

The FIR burner combines several techniques to dramatically reduce NO_x and carbon monoxide (CO) emissions from natural gas combustion without sacrificing boiler efficiency. These techniques include:

- 1) Premixed substoichiometric combustion and significant internal recirculation of partial combustion products in the first stage to achieve stable, uniform combustion that minimizes peak flame temperatures and high oxygen pockets,
- 2) Enhanced heat transfer from the first stage to reduce combustion temperatures in the second stage, and
- 3) Controlled second stage combustion to further minimize peak flame temperature.

As a result, overall NO_x formed in the combustor is minimized.

MINIMIZATION OF THERMAL AND PROMPT NO_x



Staged combustion with internal recirculation of products of partial combustion minimizes both thermal and prompt NO_x .



Project Description

Goal: Develop, field test, and ultimately commercialize a natural gas combustion system, suitable for process fluid heaters and watertube boilers in the petroleum, chemical, and steel industries.

This project includes the following objectives:

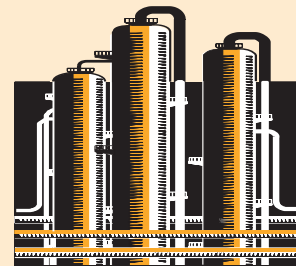
1. Achievement of NO_x emissions below 9 vppm, CO emissions below 50 vppm, and total hydrocarbon (THC) emissions below 50 vppm -- all at three percent oxygen (O_2) -- utilizing less than 10 percent excess air over a four to one turndown at all design operating conditions. No external flue gas recirculation, water or steam injection, or post combustion treatment for NO_x reduction will be used;
2. Achievement of these emissions reductions with no detrimental effect on efficiency, production rate, or ease of operation and maintenance;
3. Establishment of the economic and commercial viability.

Progress and Milestones

- Completed baseline testing at Detroit Stoker Company host boiler with conventional burner (85 vppm NO_x).
- Completed design, manufacturing, and installation of 20 million (mm) Btu per hour burner for watertube boilers.
- Demonstrated less than 9 vppm NO_x and less than 40 vppm CO over a four to one turndown ratio with low excess air at less than three percent O_2 .
- Logged more than 5,000 hours of continuous operation since September 1997.
- Identified and selected a 60 mm Btu per hour watertube boiler at a Southern California host site.
- Received experimental permit for host boiler retrofit.
- Prepared commercial burner design.
- Anticipate field testing to be completed in the first half of calendar year 1999.

Commercialization Plan

The FIR burner is applicable to a wide range of watertube boilers used in industry including paper, chemicals, petroleum refining, food, and steel. Its performance will be demonstrated on 50 to 100 mm Btu per hour boilers that are commonly used in these industries. Subsequently, Detroit Stoker Company will offer models in the range of 20 to 200 mm Btu per hour as part of its standard product line.



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January 1999